

Engineering education on geosciences in a changing world

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Engineering aims to work with what knowledge is available to achieve society's goals (Coyle, Murphy, and Grimson 2007). The current environmental challenges and the characteristics of the labour market mean that the effectiveness of Engineering activities in Geosciences must be increased through the development of technical knowledge and the inclusion of suitable training aimed at solving real cases (European Commission 2010). Human capital – understood as the talents, skills and capabilities of higher education graduates – is perceived as an essential element for sustainable economic growth and development in the globalised economy (Sianesi and Van Reenan 2003). We need, therefore, to rethink our approaches to curriculum, instruction and assessment in science education, particularly because of the rapid growth of the scientific knowledge, tools/technologies and theories that have originated over the last 50 years (Duschl and Grandy 2013).

In addition, the environment shared by Europe's university systems – the European Higher Education Area – has incorporated a series of structural reforms to make education in all European countries more compatible and comparable, as well as adapting the teaching contents and methodologies to meet social demands. In this context, the current training of the future generation of engineers in Geoscience should not only be based on assimilating their lessons but they must also become lifelong learners, flexible and well-adapted to the changing demands and be ready to evaluate their own assumptions about learning (Nguyen 2009). The success of this process depends on students being exposed to suitable self-study and problem-solving tasks, as well as learning how to learn (Lucas-Yagüe et al. 2008). Contents and pedagogical approaches should also aim at student-focused teaching, thus increasing the emphasis upon learning autonomy through well-planned active learning experiences (Almeida et al. 2010). Moreover, the tools and activities should be designed to engage and motivate students, encouraging active strategies to reinforce the learning. At the same time, long-term teaching plans and work experiences in Engineering should provide suitable opportunities for students to take considered decisions and use their critical thinking.

Among recent teaching approaches, interactive tools and virtual laboratories have brought significant improvements in autonomous learning, as have been underlined by numerous authors

in different fields of Engineering (Stumpf II, Douglass, and Dorna 2008; Machet, Lowe, and Gütlbc 2012; Christian and Esquembe 2007; Neves, Neves, and Teodore 2013). Schmorrow (2009) suggests that virtual environments will be the technology of the early twenty-first century that will most dramatically change the way we live, particularly in the areas of training and education, product development and entertainment. In line with these enhancements and the changing practices of today's socio-professional contexts in Engineering, it is worth noting the immense potential of the open-source learning platforms (such as Moodle – Modular Object-Oriented Dynamic Learning Environment) and e-learning courses to improve the digital skills (such as on-line research, widgetising, podcasting and blogging skills), which ensure individuals' increased autonomy, adaptability, lifelong learning ability and, implicitly, employability (Tănase-Robescu 2011; Kapenieks 2013).

The exploration of relationships between skills providers and employers constitutes another key aspect of making education and training more flexible, productive and innovative. Studies such as *New skills for new jobs: action now* (European Commission 2010) highlight the important role played by individuals, private and public employers, the education sector and governments at all levels as a whole in creating prosperous communities. In this context, the knowledge of different stakeholders' opinions, demands and connections constitute a crucial component in the design and implementation of suitable teaching strategies. Additionally, alternative approaches such as cooperative education – which combines classroom instructions with work experience in corporations – provide another area where notable achievement of learning outcomes has been proved (Brahimi et al. 2013).

This issue compiles a set of articles presented in the session entitled Engineering Education on Geosciences in a Changing World of the European Geosciences Union Assembly 2011, held between third and ninth April 2011. A total of 29 abstracts were received in response to the 'call for papers'. This special issue presents some of these works, grouped in two blocks: (1) innovative experiences, tools and applications of information and communication technologies (ICTs) to adapt the learning to the technological changes and (2) the exploration of society's teaching demands through the analysis of the different stakeholders involved.

The first contribution to this special issue by Gilford et al. (2014) underlines the potential for stimulating learning in students of soil science by the use of interactive virtual environments. In this work, the development of a soil atlas – created as an interactive 3D virtual environment – proves its usefulness and shows the considerable scope for increasing interest in soil sciences through the different artistic styles and levels of abstraction in the diagrams.

In the articles that follow, the role of open-source learning platforms in encouraging learning, and the substitution of traditional pedagogical methodologies based on lectures and written notes are explored in different fields. Firstly, the impact of group and individual learning strategies on reinforcing reasoning and critical attitude using on-line activities was measured by Rodríguez-Sinobas and Sánchez-Calvo (2014) on two course components about hydraulic systems in the Agricultural Engineering School of Madrid (Spain). The results showed a marked increase in motivation in students as well as an improvement in their marks. On the other hand, Losada, Borondo, and Benito (2014) showed the progress made when traditional notes are replaced with interactive online materials (e-book, online notes and assisted exercises) in course components in a Master's Degree in Physics of Complex Systems. Their analyses showed a close correlation of high marks with the use of Moodle. It is worth noting that both works highlight how students became actively involved in the learning process and implicitly show the acquisition of skills derived from the use of ICTs.

Redel et al. (2014) designed an interactive tool as a virtual lab of an agro-industrial building in order to develop and illustrate the most important aspects of a project-document (calculation, regulations, drawings and budgets), as well as the relationship with the activities that make up the work. These authors concluded that practical knowledge was highly valued by the students, as

were the transversal influences of this type of tool on other disciplines associated with Engineering projects. In addition, the final marks of the students who used the new approach were notably better.

In the second block, [Sánchez-Lavega et al. \(2014\)](#) presented the facilities set up in the University of the Basque Country (Spain) to promote the field of Space Science and Technology in both public and private sectors. The practical use of the Astronomical Observatory justified the participation and support of different international institutions such as the European Space Agency among others, thus giving the students access to basic research facilities at the University and the technology available in the space industry and space agencies.

Following a similar line of linking different institutions, [Perdigones et al. \(2014\)](#) carried out an interesting two-year study on the skills acquired by Agricultural Engineering students in the Technical University of Madrid (Spain), the skills required by agricultural employers and those required by farming sector professionals and former students. These authors concluded that farming sector employers preferred generic skills such as the ability to coordinate groups/places to knowledge of specific disciplines. As for software skills, similar tendencies were observed, with a high demand for generic programmes such as Microsoft Office. These aspects were taken into account when redesigning the contents of several course components, in order to improve the integration of future Agronomy engineers.

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